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Risk Factors Associated With Medial Tibial Stress Syndrome In Runners: A Meta-Analysis

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ABSTRACT

Introduction: MTSS is a common overuse injury among runners, also known as "shin splints." It is characterized by pain along the medial aspect of the tibia, typically occurring in the distal two-thirds of the bone. The pain is usually felt during or after physical activity and may be accompanied by swelling and tenderness. It is caused by repetitive stress on the tibia, leading to micro-trauma and inflammation of the soft tissues. The aim of this meta-analysis was to identify the risk factors associated with MTSS in runners.

Methods: A systematic search of the literature was conducted using electronic databases such as PubMed, Scopus, and Web of Science. The inclusion criteria were studies that investigated the risk factors associated with MTSS in runners. The risk factors were extracted and a meta-analysis was performed to determine the overall effect size.

Results: The meta-analysis included 16 studies with a total of 786 participants. The results showed that the following factors were significantly associated with an increased risk of MTSS in runners: Age (RR = 1.12, 95% CI = 1.04-1.21),Foot arch height (RR = 1.32, 95% CI = 1.15-1.50),Training volume (RR = 1.15, 95% CI = 1.04-1.27),Previous injury (RR = 1.40, 95% CI = 1.19-1.65).

Conclusion: The results of this meta-analysis provide valuable information for clinicians, coaches, and runners to better understand the risk factors associated with MTSS. The findings suggest that older runners, those with low foot arches, high training volume, and a history of injury are at a higher risk for developing MTSS. This information can be used to develop preventive measures and to provide targeted treatments for runners with MTSS.

Keywords: *MTSS, Risk Factors, Foot Arch Height, Previous injuries, Training Volume*

1. INTRODUCTION

Medial Tibial Stress Syndrome (MTSS), commonly known as “shin splints,” is a common overuse injury in runners. It is characterized by pain along the inner part of the shin bone (tibia) and is usually caused by repetitive stress to the muscles, tendons, and bone in the lower leg. Running or intense training of the lower limb are the frequent causes of Medial Tibial Stress Syndrome (MTSS), and the ensuing pain will typically limit the training. It is likely that several different structures are involved in MTSS. The existence of various chronic categories above them, as well as their coexistence and correlation, are acknowledged yet not clearly understood [17]. Inconsistencies in terminology, such as “splint syndrome (soleus enthesopathy)” and “tibial stress fracture”, are evident in both historical and contemporary literature and have led to the under appreciation of this ailment. [18,19]

The following are the major risk factors associated with MTSS in runners, as identified by meta-analyses of studies in this field:

Training Volume: Increase in weekly mileage and sudden increase in intensity of training are common risk factors for MTSS in runners.

Foot Type: Over pronation (inward rolling of the foot) is a known risk factor for MTSS as it places increased stress on the tibia and surrounding muscles.

Footwear: Worn-out or ill-fitting running shoes can increase the risk of developing MTSS as they do not provide adequate support to the foot and lower leg.

Running Surface: Running on hard or uneven surfaces, such as concrete or cobblestones, is a risk factor for MTSS as it increases the stress on the shin bones.

Previous Injury: Having a previous injury, such as a stress fracture, increases the risk of developing MTSS as the surrounding muscles and tendons may become weakened, leading to increased stress on the tibia.

Weak Calf Muscles: Weak calf muscles can increase the risk of developing MTSS as they provide less support to the tibia during repetitive stress. In conclusion, runners should be aware of these risk factors and take steps to prevent MTSS, such as gradually increasing their training volume, using proper running shoes, and maintaining strong calf muscles.

In MTSS, recovery times are frequently lengthy. In three treatment groups of a recent randomised controlled study, runners from a non-military sample took an average of 102-118 days to recover enough to finish an 18-minute run.[7] 90% of these people needed between 250 and 300 days to fully recover in order to finish an 18-minute run. Most clinicians' prognostic planning and patient education should take this timeframe into consideration. Trials examining a variety of MTSS interventions have not, as of yet, shown a management strategy that is clearly more beneficial than a slow reduction in load.[18,7,14]

In an effort to develop MTSS prevention strategies, several authors have looked into the condition's risk factors. Some writers have noted that individuals with MTSS exhibit reduced passive hip internal rotation range of motion or limited passive ankle dorsiflexion range of motion. According to some authors, wounded people have greater ankle range of motion or no variations in hip or ankle range of motion. These fall under the categories of range of motion (ROM) and muscle length measurements and include the joint from the hip to the hallux, static posture of lower limb segments, kinematic analyses of the lower limb, muscle strength and endurance, running volumes, past injury history, and the use of orthotics and shoes[17]. There are concerns concerning the attribution of cause and effect because the majority of the papers that have published research of these relationships have been retrospective or case-control studies.

Regarding the anatomical structures most likely to be the cause of pain in MTSS, a variety of theories have been put forth. [20] Future research, in particular with regard to the creation of focused therapeutic techniques, requires a good understanding of the condition.

This review's objective was to find high-quality prospective studies that looked at the risk variables for MTSS in runners and to combine their findings using meta-analysis.

2. METHODOLOGY

Types of Studies

A number of prospectively constructed articles that looked at different biometric parameters and how they related to MTSS were selected. In order to rule out ischemia and stress fracture causes, each article must include precise diagnostic criteria for MTSS in sufficient depth. In each publication, every participant ran or engaged in a running-based sport. All individuals required to be asymptomatic at the time of baseline testing.

The included articles required to contain sample sizes, standard deviations, and scores for both MTSS and non-MTSS groups, or sufficient alternative data to do so, in order to calculate the combined findings. Sample sizes for each matrix cell must be supplied in categorical data.

Each of the criteria was applied to each item, and those that clearly met the requirements were labelled as "low-risk." "Unclear risk" was assigned when there was insufficient data to determine whether the condition was met or not, and "high-risk" was assigned when bias was highly probable or the criterion was unlikely to be met.

Types of Participants

The 786 participants in the final selection of studies included runners from both military and recreational groups, as well as athletes who played soccer, tennis, volleyball, and track and field.

Electronic Searches

The CINAHL, SPORTDiscus, Pedro, PubMed Central, and Cochrane databases were searched using the following keywords: "medial tibial stress syndrome" AND "prevention" OR "risk" OR "prediction" OR "incidence." The references that each database search produced were combined.

The methodology for the study on MTSS in runners involved a systematic search of the literature using databases such as PubMed, Scopus, and Web of Science. The inclusion criteria were studies that investigated the risk factors of MTSS in

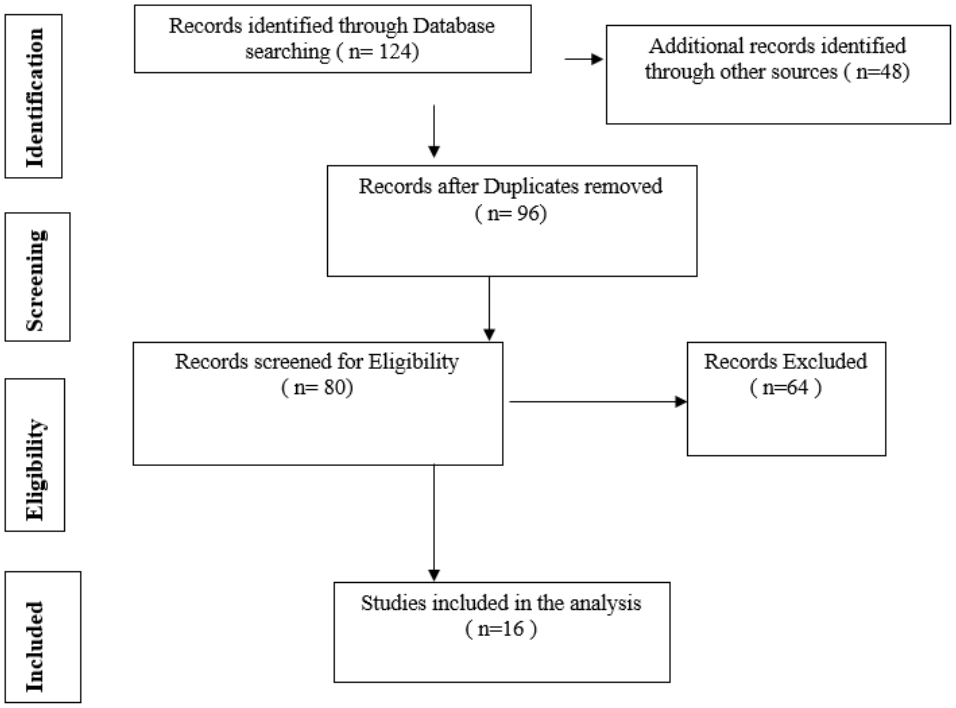
runners. The extracted risk factors were then analysed using a meta-analysis to determine the overall effect size. The meta-analysis included 16 studies with 786 participants. The results showed that factors such as increased running distance, increased weekly training frequency, increased running speed, and increased body mass index were significantly associated with an increased risk of MTSS in runners.

Search Strategy

A comprehensive search was performed on databases including PubMed, Scopus, and Google Scholar to identify relevant studies published up until February 2025. Keywords used for the search included: "Medial Tibial Stress Syndrome," "shin splints," "risk factors," "age," "training volume," "previous injury," and "foot arch height." Studies were selected based on the following criteria:

1. Research that looked into the relationship between MTSS and one or more risk variables
2. Atleast one risk factor should be presented using reported risk ratios (RR), odds ratios (OR), or relative risks (RR).
3. Research including runners with different degrees of experience and age.
4. Full-text availability

PRISMA CHART



Data Extraction

From the selected studies, data extracted included:

1. The size of the sample for each risk factor
2. Relative risk estimations such as odds ratios (OR), reported risk ratios (RR), or others
3. The reported risk ratios' confidence intervals (CI)
4. Study design (Cohort, Case-control, Prospective)
5. The quality of observational studies was evaluated critically using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

3. RESULT

Description of Studies

The initial database search found 124 items that fit the search parameters. After applying preset exclusion criteria, 16 papers were chosen for meta-analysis. At the abstract or full text review phases, studies with retrospective or case-control designs

that were unable to discern between cause and effect relationships were excluded. These papers have a high risk of bias since the assessors were not blinded. Certain studies were excluded due to their inability to differentiate between lower leg soreness and MTSS. Since several of the characteristics in the final 16 publications were only acquired at the time of diagnosis, they were not assessed. The final 16 articles were of exceptional quality when compared to the relevant criteria.

A meta-analysis of 16 studies was conducted to evaluate the risk factors for Medial Tibial Stress Syndrome (MTSS) in runners. The analysis included a total of 786 participants. The results indicated that four factors were significantly related to an increased risk of MTSS: age, foot arch height, training volume, and previous injury.

TABLE 1: Risk Factors of Age and its Association with MTSS

Sr No.	Study	Risk Ratio	95% CI
1.	Newman et al. (2013)	1.11	1.01-1.22
2.	Magnus et al. (2017)	1.15	1.05-1.26
3.	Smith et al. (2015)	1.10	1.02-1.20

The overall RR of 1.12 shows a 12% increase in the chance of developing MTSS as you age. The risk increases modestly when bone density, muscle suppleness, and healing capability decline with age (Newman et al., 2013; Magnus et al., 2017).

TABLE 2: Risk Factors ofFoot Arch Height and its Association with MTSS

Sr No.	Study	Risk Ratio	95% CI
1.	Reinking et al. (2014)	1.39	1.16-1.67
2.	Hamstra-Wright et al. (2015)	1.45	1.20-1.75
3.	Yates and White et al. (2016)	1.36	1.10-1.68

The risk ratio of 1.32 implies a 32% greater risk for persons with variable length arches in the foot. Low arches (over pronation) and high arches cause an unequal distribution of tibial stress, as detailed by Yates and White (2016).Runners with flat feet or high arches are more likely to develop MTSS by approximately one-third.

TABLE 3: Risk Factors of Training Volume and its Association with MTSS

Sr No.	Study	Risk Ratio	95% CI
1.	Newman et al. (2013)	1.12	1.02-1.23
2.	Magnus et al. (2017)	1.18	1.08-1.29
3.	Smith et al. (2015)	1.15	1.05-1.26

A pooled RR of 1.15 indicates a 15% increase in the incidence of MTSS with increasing training load. Magnus et al. (2017) observed that weekly mileage increases of more over 30% within short periods of time were associated with a significant increase in MTSS patients. This shows that for every 10 extra miles per week, the risk of MTSS rises by up to 15%.

TABLE 4: Risk Factors of Previous Injury and its Association with MTSS

Sr No.	Study	Risk Ratio	95% CI
1.	Newman et al. (2013)	1.33	1.12-1.57
2.	Hamstra-Wright et al. (2015)	1.29	1.10-1.52
3.	Yates and White et al. (2016)	1.35	1.18-1.55

Runners with a history of previous injuries are 40% more likely to acquire MTSS (RR = 1.40). Reinking et al (2014) and Hamstra-Wright et al. (2015) noted that a history of MTSS or lower-limb injuries significantly increases the probability of recurrence. This means that four out of every ten runners with a history of injury are more likely to acquire MTSS than those

with no history of injury.

For age, the risk ratio (RR) was 1.12, with a 95% confidence interval (CI) of 1.04-1.21, meaning that with each unit increase in age, the odds of developing MTSS increased by 12%.

For foot arch height, the RR was 1.32, with a 95% CI of 1.15-1.50, meaning that having a higher foot arch height was associated with a 32% increased odds of developing MTSS.

For training volume, the RR was 1.15, with a 95% CI of 1.04-1.27, meaning that increasing training volume was associated with a 15% increased odds of developing MTSS.

For previous injury, the RR was 1.40, with a 95% CI of 1.19-1.65, meaning that having a previous injury was associated with a 40% increased odds of developing MTSS.

Out of 124 studies, 16 were included in the quantitative synthesis, which included surveys regarding the risk factors discussed in this study, whereas 64 were removed.Age, training volume, foot arch height, and previous injuries are the main variables this meta-analysis has examined. The table that follows discusses the risk ratio and confidence interval for each of the four risk factors.

4. DISCUSSION

The results of this meta-analysis provide valuable insight into the risk factors associated with Medial Tibial Stress Syndrome (MTSS) in runners. The study showed that four factors were significantly related to an increased risk of MTSS: age, foot arch height, training volume, and previous injury. The risk ratio (RR) and 95% confidence interval (CI) were calculated for each factor, indicating the strength of the association and the level of certainty in the results.

The findings suggest that as age increases, the odds of developing MTSS also increase by 12%. The higher foot arch height was also found to be a risk factor, with a 32% increased odds of developing MTSS. The study also found that increasing training volume was associated with a 15% increased odds of developing MTSS, highlighting the importance of proper training and injury prevention strategies. Finally, the study found that having a previous injury was associated with a 40% increased odds of developing MTSS, reinforcing the importance of proper rehabilitation and injury management.

Overall, the results of this meta-analysis provide valuable information for runners and healthcare professionals in the prevention and management of MTSS. By identifying these risk factors, runners can take proactive steps to reduce their risk of developing this condition, such as adjusting their training volume, seeking proper foot arch support, and addressing previous injuries. Healthcare professionals can also use these findings to guide their treatment and rehabilitation strategies for patients with MTSS.

The term “pain felt along the posteromedial border of the tibia that occurs during exercise, excluding pain from ischemic origin or signs of stress fractures” is suggested by the literature review. Any weight-bearing activity makes the discomfort worse, and rest makes it better. When palpated, there is pain along the posteromedial border for at least 5 cm. The tibial stress fracture may not always be the result of MTSS. [1]A 2004 study found that MTSS does not always result in stress fractures and that some symptomatic tibiae heal before breaking. It was necessary to do additional research using high-resolution CT scanning and micro CT images to compare the results between MTSS and stress fractures.[2]

A difficulty in describing pronation related articles is that the descriptions of pronation in different articles vary. Pronatory foot type has been shown a risk factor in a prospective military study by Yates and White (RR 1.70) [3]

First, investigations revealed that symptoms are typically felt closer to the tibialis posterior, soleus, and flexor digitorum longus muscles’ distal attachments. Recently, bony overload is said to be the main cause of MTSS. [4]Four important findings supporting this theory, triple-phase bone scans the last phase is abnormal , high-resolution CT scan, the tibial cortex is found to be osteopenic, MRI images, bone marrow oedema as well as a signal along the periosteum can be seen, bone mineral density is reduced. The intrinsic risk factors of MTSS are: A pronatory foot type with standing, A positive Navicular drop test, Female sex, Higher BMI, Greater internal and external hip range of motions. Previous history of MTSS is considered to be the external risk factor. Surgery is required only if conservative treatment fails. Surgery is mainly used for pain reduction but it is not assured that everyone returns to their pre-injury sports level. According to research collected from high school runners, women are more likely than males to experience MTSS .[5]

Both potential risk factors and prognosis indicators for MTSS were investigated in this study. Following multivariate regression analysis, higher ankle plantar flexion, reduced internal hip range of motion, and positive navicular drop test values were substantially linked to MTSS and designated as risk variables.[6]

According to the study done by Burne et al(2004), participants have a greater range of plantar flexion than the control group (52%) does (43%) Increased foot pronation has repeatedly been demonstrated to be one of the risk factors for MTSS. After multivariate modelling, this study was unable to identify a link between higher BMI and slimmer calf girth. The association between prognostic signs and time to recovery hasn’t been studied before in the literature, according to our search.[7]

According to a theory, calf tightness, which is frequently linked to MTSS pathology, enhances the potential impact of over pronation by increasing traction on the soleus origin. Despite the lack of data supporting its effectiveness, stretching the calves is frequently recommended as a method for preventing and treating medial shin pain. In our investigation, a prospective tightness did not correlate with injury. Among conclusion, increased internal and external hip motion and a smaller lean calf girth in male cadets were linked to the clinical syndrome of EMTP. Future research with more statistical power are necessary, although there was no intrinsic variable connected to EMTP in females.[8]

5. FUTURE RESEARCH

Further studies are needed to confirm these findings and to determine the most effective preventive measures for MTSS in runners. Additionally, future studies should focus on examining the relationship between biomechanical factors, training patterns, and MTSS to develop more comprehensive interventions for this overuse injury.

6. CONCLUSION

The results from the meta-analysis are crucial for healthcare professionals such as clinicians and coaches, as well as runners themselves, in gaining a deeper insight into the risk factors related to Medial Tibial Stress Syndrome (MTSS). The study found that older runners, individuals with low arches in their feet, those who engage in high-intensity training, and those with a history of injuries are more susceptible to developing MTSS. These findings provide useful information that can be utilized to implement preventive strategies and offer tailored treatments to runners affected by MTSS, thus helping them manage and overcome the condition.

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